SCHOFIELD BARRACKS MILITARY RESERVATION, KU TREE RESERVOIR, SPILLWAY **HAER No. HI-81-D**
Kalakoa Stream
East Range
Wahiawa Vicinity
Honolulu County
Hawaii

PHOTOGRAPHS

WRITTEN HISTORICAL AND DESCRIPTIVE DATA

HISTORIC AMERICAN ENGINEERING RECORD
National Park Service
Department of the Interior
1849 C Street, NW
Washington, D.C.

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Location:	Kalakoa Stream (Tributary to the South Fork of Kaukonahua Stream) Approximately 3 miles east of Wahiawa East Range, Schofield Barracks City and County of Honolulu Hawaii USGS 7.5 minute series topographic map, Waipahu, HI 1998 Universal Transverse Mercator (UTM) coordinates: 04.605640.2377530
Date of Construction:	1922-1925
Engineers & Builders:	Office of the Quartermaster General and Office of Chief of the Fourth Construction District
Present Owner:	U.S. Army
Present Occupant:	U.S. Army (training area)
Present Use:	Reservoir drained, spillway not in use.
Significance:	The spillway is significant as an element of the Ku Tree Reservoir and as a good example of a spillway constructed for an earth-fill dam in Hawaii in the 1920s. The spillway embodies the distinctive characteristics of its type, period, and method of construction, while possessing high integrity. While the individual elements of the design are typical, such as the utilitarian pedestrian bridge, overall it is a notable example of this type of engineering structure in Hawaii. Because of Ku Tree Reservoir's capacity and the size of its watershed, its spillway, with a length of 460' and 68 percent slope, is one of the more impressive spillways in the state.
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Date:	June 2008

For additional information see the main report on the Ku Tree Reservoir (HAER No. HI-81), as well as the individual reports on the other related structures in this complex (HAER Nos. HI-81-A, HI-81-B, and HI-81-C).

DESCRIPTION

The Ku Tree Reservoir's reinforced-concrete spillway is a fixed-crest type with no control structures. It is situated on the east abutment of the dam, approximately 140' from the eastern edge of the dam's crest. The axis of the spillway's crest is slightly skewed, about 20 degrees, from the centerline of the dam. Traversing a natural hillside, it is a chute spillway with a large drop in elevation. Starting at an elevation of 1,080'-0", the spillway floor drops to an elevation of approximately 987' over a horizontal distance of approximately 410'. At the top, on the reservoir side of the crest, there is a concrete apron approximately 160' wide and 20' deep; this flat, rectangular area is about a foot lower than the spillway crest. From the crest elevation of 1080' there is an 8'-0" ogee-curved drop in the spillway. The concrete side walls at the base of this drop are about 13' high. The year "1924" is incised in the concrete of the west side wall, not far from the spillway's crest (although a 1925 completion date was reported in the February 21, 1925 *Honolulu Advertiser*). The large flat area near the top of the spillway is funnel shaped, and its walls converge from the 160' width at the foot of the first drop to a 30' wide chute. From this point the spillway drops into a stilling basin approximately 100' lower than the spillway crest.

In the initial 120' (of horizontal distance from the funnel-shaped flat area) the spillway continues the axis of the funnel, but drops steeply at a 68 percent slope. About halfway down this steep section, on the east wall, a surface drain pipe empties into the chute. The next two sections of the chute are less steep and are curved in a gentle S shape. After its initial precipitous drop the spillway curves to the right approximately thirty degrees and assumes a gentle slope of about five percent for 90 feet, before bending to the left approximately 16 degrees. After that bend, part of the section has a slope of less than four percent for approximately 40', and the other part is a level stilling basin, about 50' in length. This basin is created by another ogee-shaped weir, projecting about 3' in height above the spillway floor here. The final section of the spillway, also essentially level, has its axis at a 30-degree angle from the stilling basin; water in the spillway travels this final 40' before emptying into a stream.

The side wall heights of the spillway vary quite a bit. At the apron, they are about 6' tall, but at the first ogee-shaped drop, the walls are about 13' high. These walls step down to about 8' as the flat, funnel-shaped area narrows towards the chute. There are metal rungs imbedded in the concrete of these side walls, providing ladders to access this part of the spillway. In the chute part of the spillway, the side walls are 5'-0" tall along the steep section, but become 7'-0" high in the curving sections, and then are about 9' in height at the stilling basin end. Ladder rungs are also set in the walls of the stilling basin, just upstream of the ogee weir. Wing walls, set at 90 degrees from the chute walls, terminate the spillway structure; these anchor it into the natural hillside, penetrating the hill to a depth of several feet. The spillway was designed to accommodate a peak flood discharge of 8,100 cubic feet per second.

The spillway's floor thickness is generally 8", but at several points, i.e., the ogee weirs and where the slope changes abruptly from 68 to about 6 percent, the concrete base is more complicated in design and much thicker. The portions of the spillway floor just before and after the second ogee weir are 12" thick. The reinforcing used in the spillway floor is labeled as "Clinton mesh."

Approximately 86' from the spillway crest, at the funnel part near the steep chute section, a reinforced-concrete spillway footbridge crosses over the spillway. It allows people to access the top of the Ku Tree Reservoir dam and the former bridge to the valve tower. The bridge is a straightforward, three-span, reinforced-concrete structure. It measures approximately 79' in length and 3'-6" in width. It is supported by the spillway walls at the abutments and by two 10"-square concrete columns. Diversion ribs on the upstream side protect the columns from the current and debris in the spillway waters. The reinforced-concrete diversion ribs are 1'-6" high, and 1'-2" inches wide, and angle out 45' from the columns towards the top of the spillway. The bridge deck is 4" thick and in section is a single web T with the beam below the bridge deck measuring 10" wide and 8" deep. The handrails are 3'-0" high and originally made of 1½"-diameter steel pipes. However, the original pipe handrails were replaced in the past twenty-five years. The new rail is made of 2"- and 3"-diameter pipes.

The spillway retains its integrity, and there have been no alterations or additions made to it, other than the replacement of the spillway bridge's pipe handrail. Because of disuse, especially since the 1983 drawdown of the reservoir, dense vegetation grew over most of the spillway's floor. Vegetation clearing was done in April 2008 to allow photographic documentation of the spillway.

HISTORY

The spillway was designed and constructed as an integral part of the Ku Tree Reservoir. A spillway is an essential part of an earth-fill dam, as the principal disadvantage of this type of dam is that it will be damaged or even destroyed if overtopped by flood waters. Spillways serve to release excess flood waters which cannot be contained in the reservoir. An inadequately sized spillway is the major cause of failure in earth-fill dams. Therefore, a spillway with sufficient capacity is critical for the safe operation of this type of dam. The spillway needs to be located at a sufficient distance from the dam to prevent dam erosion and must be sited so that its discharge will not erode or undermine the downstream toe of the dam. In addition, the spillway needs to be erosion-resistant and able to withstand high scouring velocities that result from the drop between the reservoir surface and the bottom elevation. When located on soil or deeply weathered rock, the entire length of a spillway is always of concrete. A stilling basin is designed at the terminal end of a spillway to prevent erosion where the overflow empties into the original stream.

Planning for the Ku Tree Reservoir began in 1919 when a site visit was made by representatives of the construction service, attached to the Quartermaster General in Washington D. C., and some drawings were prepared. A spillway was included in these 1919 plans. The designer of the spillway is not known, as there are only initials on the original drawings. The sheets (6 and 8) for the spillway were drawn by G. N. in June 1924, and traced by him in November 1924.

Other spillways in Hawaii of comparable or grander scale with precipitous drops include Lake Wilson on Oahu, Keaiwa Reservoir on the island of Hawaii, and Alexander Reservoir on Kauai. The latter is the most spectacular spillway in the islands.

As is typical for spillways in earth-fill dams, this element of the Ku Tree Reservoir is isolated from the dam, traversing the natural abutment outside the limits of the dam. Its crest is at an elevation 5'-0" below the crest of the dam. This is the minimum variance in elevation recommended in a 1907 engineering book, *Design and Construction of Dams*, which suggested the spillway should be 5' to 25' below the top of the dam (Wegmann, 1907: 225).

The chute-type spillway, because of its simplicity of design and construction, was the most common form to be employed for earth-fill dams. Spillways could incorporate a control device to regulate the outflow of water, or be a fixed system, which simply allows the water to overflow the crest. The latter is the case at Ku Tree Reservoir. As is typical in fixed-system design, an ogee weir at the crest softens the fall of the floodwater's or released excess water's overflow and reduces erosion at the base of the weir. Usually chute-type spillways are straight runs; however, the Ku Tree spillway has four different axes as it descends the hillside. These shifts in the chute's alignment allow the spillway to follow the natural contour of the knoll which it traverses and to have a straight discharge into the original streambed. The stilling basin and its ogee weir at the lower end of the spillway were also standard elements in chute spillways of the period. These devices were used to dissipate the velocity of the flood waters before they entered the stream channel, thereby minimizing stream bed erosion.

The spillway's use of reinforced concrete as its construction material was typical for its period. Since at least the turn of century, it was common practice to construct masonry spillways in order to reduce any chances of erosion. A concrete spillway also better withstood scouring and eliminated the opportunity for overflowing waters to percolate into the ground and compromise the integrity of the earth-filled dam. It certainly must have been a great effort to bring and pour the concrete for this spillway in the 1920s, since the difficulty of transporting concrete into this remote site was noted in a 1983 report (Walter Lum Associates, Inc. 1983: 21).

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PROJECT INFORMATION

See main report for Ku Tree Reservoir, HAER No. HI-81.

Figure 1: General Plan, Spillway, Ku Tree Reservoir. Job No. S3603, Sheet 6, dated June 14, 1924.

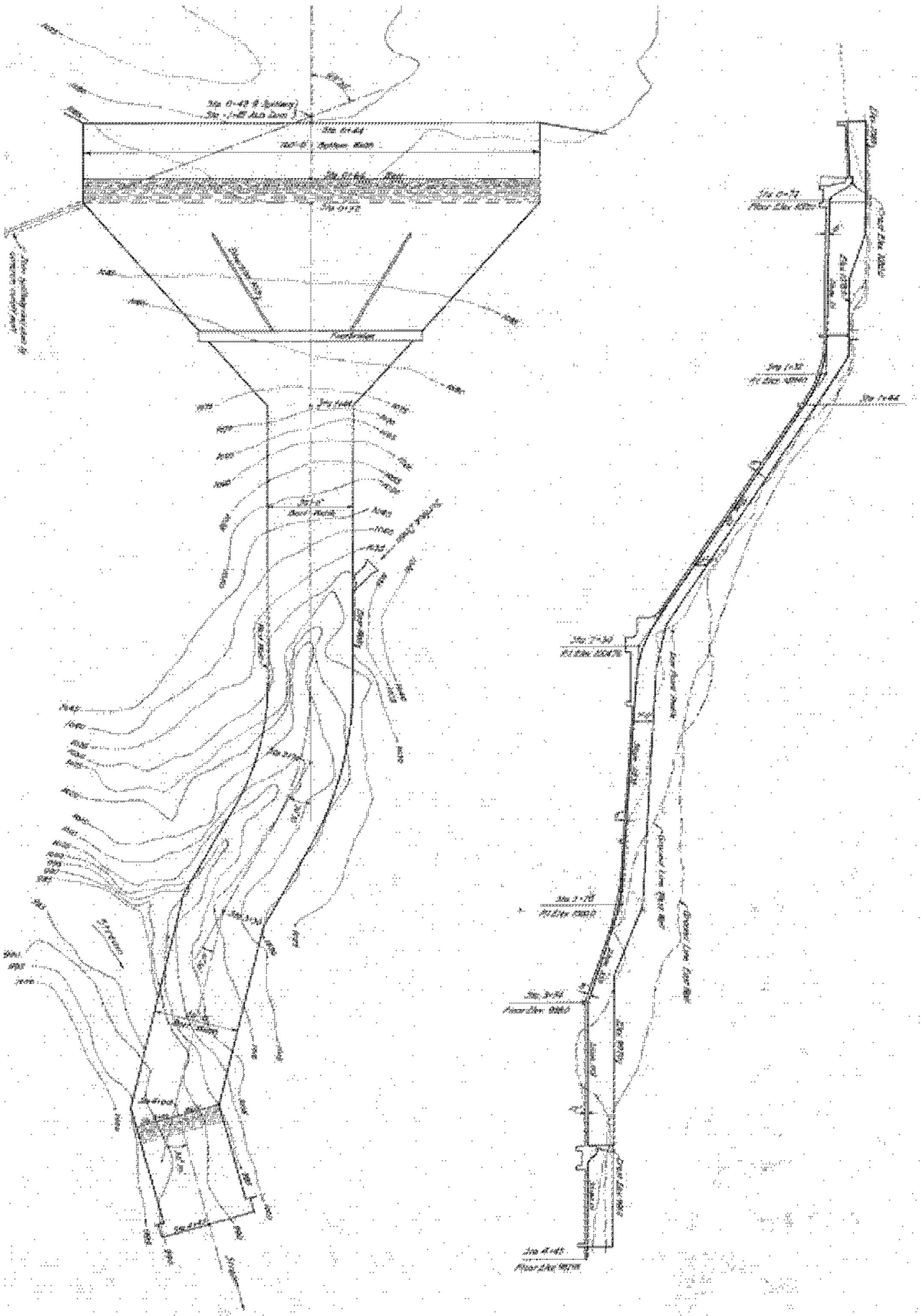

Figure 2: Plan and Section, Lower Half of Spillway, Ku Tree Reservoir. Job No. S3603, Sheet 8, dated June 14, 1924.

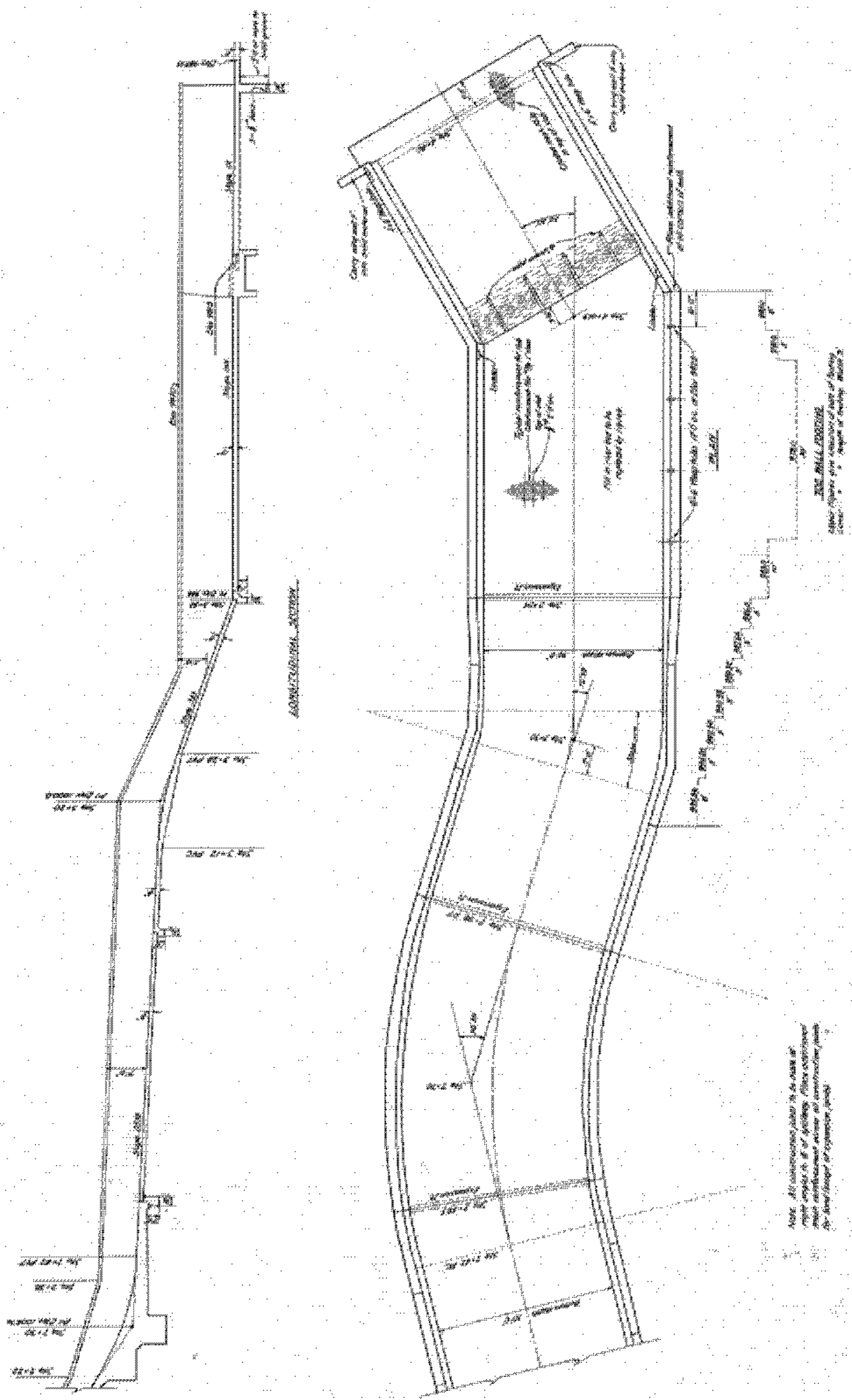

Figure 3: View in 1925 with stilling pond in foreground. (Tropic Lightning Museum, Schofield Barracks, Hawaii, Historical photograph 87.76.01-28)